MOBILE COMPUTING

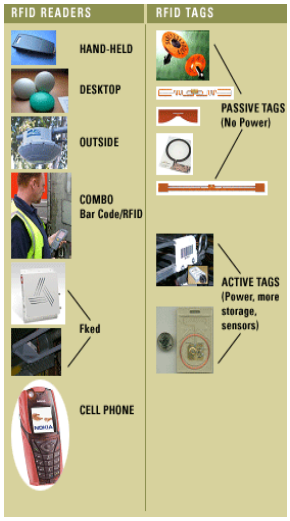
CSE 40814/60814
Spring 2021

What is RFID?

- **R**adio **F**requency **ID**entification

RFID

- **ADC** (automated data collection) technology that uses radio-frequency waves to transfer data between a **reader** and a **movable item** to identify, categorize, track...
- RFID is fast, reliable, and does not require physical sight or contact between reader/scanner and the tagged item
- A close cousin to sensor network technology
- Generally, RFID tags are cheaper, but less "intelligent" than sensor nodes
- As things evolve the line between the two technologies is blurring



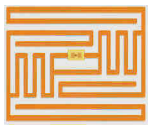
Some Historical Background

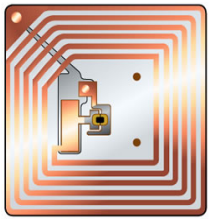
- **Identification Friend or Foe (IFF)** Used by Allied bombers during World War II
- In 1948, concept of **passive RFID** systems introduced by Harry Stockman
- In 1972, Kriofsky and Kaplan designed and patented an "inductively coupled transmitter-responder" (2 antennas)
- In 1979, Beigel designed/patented "identification device" which combined both antennas into one
- In the 1970s, a group of scientists at the Lawrence Livermore Laboratory (LLL) build a handheld receiver stimulated by RF power for secure access to nuclear facilities

RFID Systems

Main components:

- **Tags** (transponders)
  - Microchip & antenna



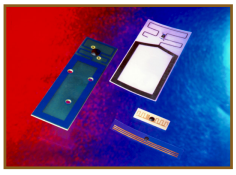


- **Tag reader**
  - Decoder & antenna
  - RFID reader sends pulse of energy and waits for response
  - Can be on all the time or activate only in response to external event

Tags

Variations:

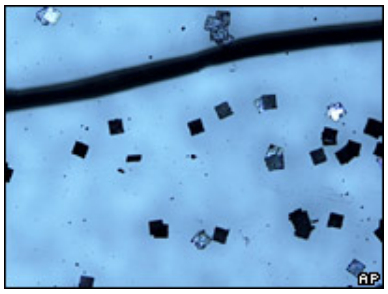
- Memory
  - Size (16 bits - 512 Kbytes)
  - Read-Only, Read/Write or WORM
- Arbitration (Anti-collision)
  - Ability to read/write one or many tags at a time
- Frequency
  - 125KHz - 5.8 GHz
- Price
  - $0.10 to $250
- Physical Dimensions
  - Thumbnail to Brick sizes



“Mission Impossible”

Tiny Tags

- 2007 Hitachi produced RFID device measuring 0.05×0.05 mm, and thin enough to be embedded in a sheet of paper. The data contained on them can be extracted from as far away as a few hundred meters. Human hair comparison.



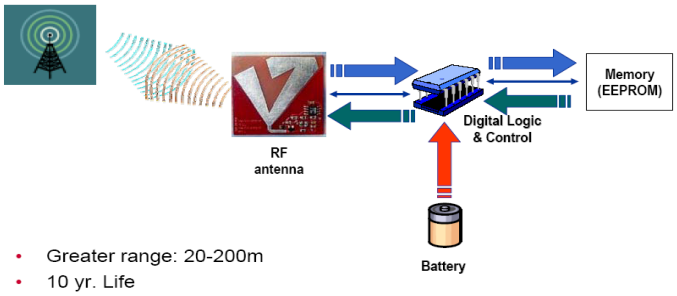
Active versus Passive

	Active RFID	Passive RFID
Tag Power Source	Internal to tag	Energy transferred using RF from reader
Tag Battery	Yes	No
Required signal strength	Very Low	Very High
Range	Up to 100m	Up to 3-5m, usually less
Multi-tag reading	1000's of tags recognized – up to 100mph	Few hundred within 3m of reader, about 3 sec per read => at most 3 mph.
Data Storage	Up to 512 KB	16 bits – 1 KB

Frequency Ranges

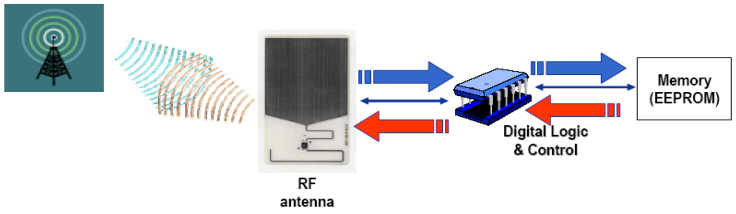
FREQUENCY BAND	CHARACTERISTICS	TYPICAL APPLICATIONS
LOW 100-500 KHz	SHORT TO MEDIUM READ RANGE INEXPENSIVE LOW READ SPEED	ACCESS CONTROL ANIMAL IDENTIFICATION INVENTORY CONTROL
HIGH 10-15MHz 850-950MHZ	SHORT TO MEDIUM READ RANGE POTENTIALLY INEXPENSIVE MEDIUM READING SPEED	ACCESS CONTROL SMART CARDS
ULTRA-HIGH 2.4-5.8 GHZ	LONG READ RANGE HIGH READING SPEED LINE OF SIGHT REQUIRED EXPENSIVE	RAILROAD CAR MONITORING TOLL COLLECTION SYSTEMS VEHICLE IDENTIFICATION

Active Tag



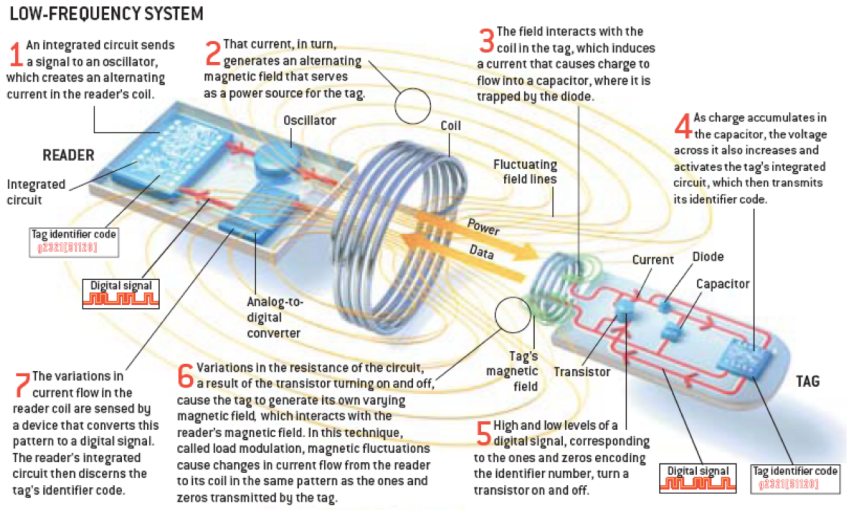
- Greater range: 20-200m
- 10 yr. Life
- Limited sensor capabilities
- "Self-powered" uses interrogator RF beam for wake-up and communication

Passive Tag

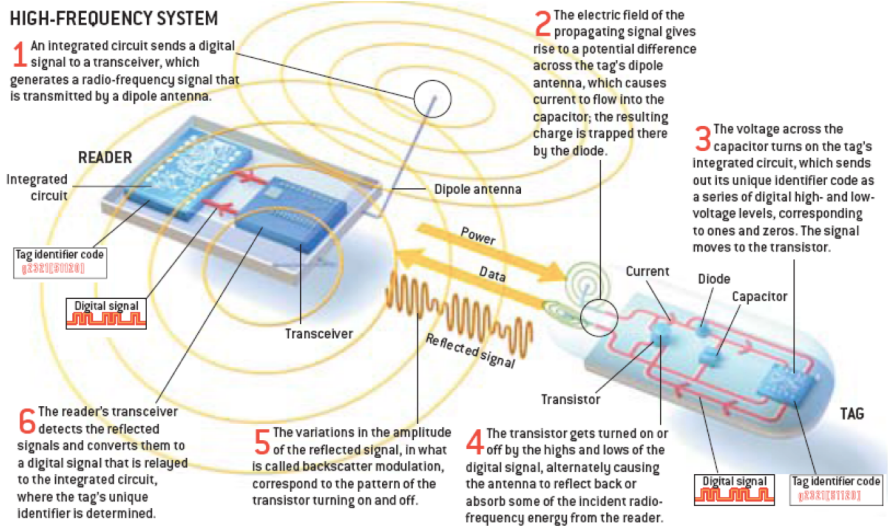


- Limited range: <10m (frequency dependent)
- Communication & power from interrogator RF beam

Low Frequency: Load Modulation



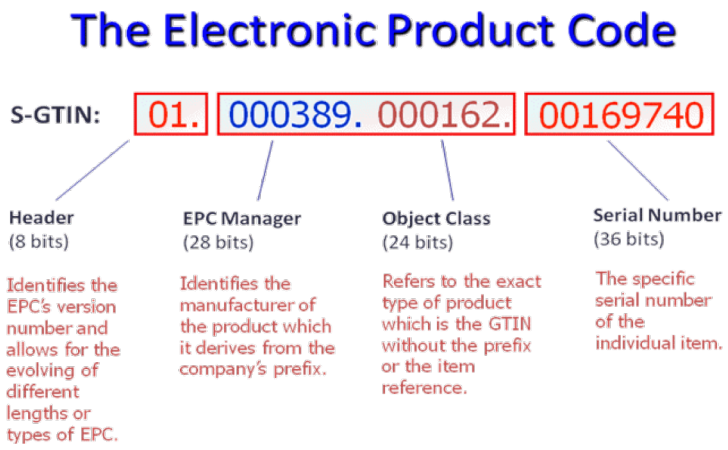
High-Frequency: Backscatter Modulation



Codes

Bar Code

EPC: Electronic Product Code



Communication and Collisions

- Very simple packet formats
  - General structure:

Sync	Header	Command	Data	CRC

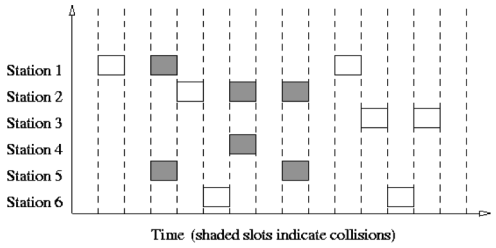
  - Usually reader-to-tag and tag-to-reader format somewhat different.
  - Typically 2 byte CRC

Collisions

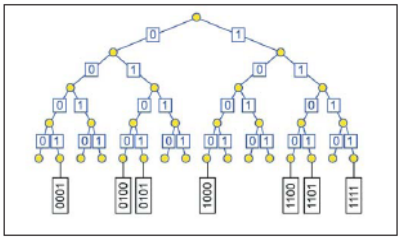
- All tags receiving query will respond: collisions!
- Many readers feature “simultaneous read” capabilities (resolve collisions)
- No “carrier sense” possible

Approach 1: Slotted Aloha

- One of the earliest and simplest medium access control protocols
- Aloha: access medium whenever ready to transmit
- Slotted Aloha: only access medium at beginning of slot (can reduce occurrence of collisions)
- Tags choose random backoff (reader can acknowledge tag ID and that tag will not send anymore)



Approach 2: Binary Tree Algorithm



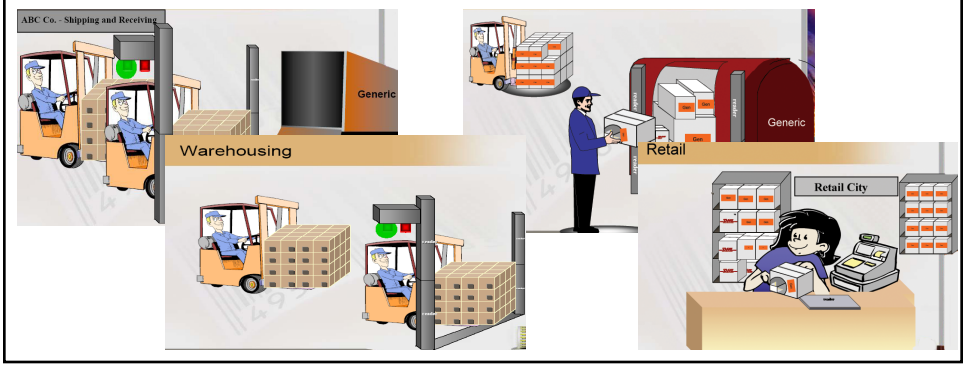
- Poll tags bit-by-bit
- Example (figure):
  - Query “x”: 7 tags respond: collision
  - Query “0x”: 3 tags respond: collision
  - Query “00x”: 1 tag responds
  - Query “01x”: 2 tags respond: collision
  - Query “010x”: 2 tags respond: collision
  - Query “0100x”: 1 tag responds
  - Query “0101x”: 1 tag responds
  - Query “011x”: no response
  - Query: “1x”: 4 tags respond: collision
  - Query: “10x”: 1 tag responds
  - Query: “11x”: 3 tags respond: collision
  - …

Application Scenarios

- Track the movement of consumer product goods
- Animal identification/tracking/counting
- Toll collection
- Implantation of RFID chips into people, e.g., Alzheimer patients

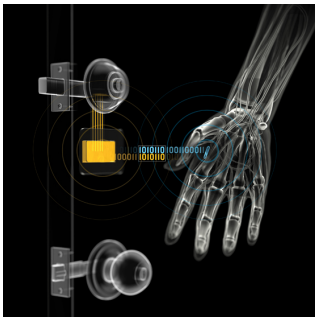
Applications

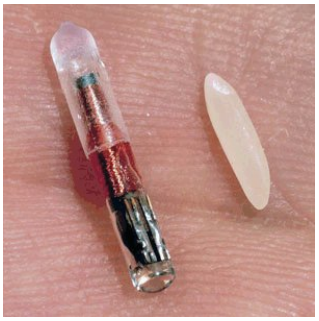
- Keyless entry
- Proximity cards
- Supply chain management



Implants

- It is the most controversial application
- Small glass cylinders approximately 2 or 3mm wide and between 1 and 1.5cm long
- Consists of a microchip, a coiled antenna, and a capacitor
- Implanted typically under the skin of arm or the back of the neck

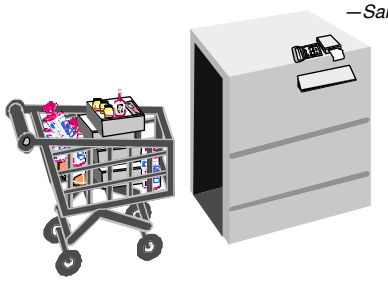




Instant Checkout?

"Chip to remove shopping blues"
—Post-Courier, January 1994

"1.5¢ electronic bar code announced"
—San Francisco Chronicle



"Tiny microchip identifies groceries in seconds."
—Chicago Tribune

"Scanning range of four yards"
—NY Times

"Checkout in one minute"
—The Times, London

Concerns

- Clandestine tracking
- Inventorying

Security/Privacy Issues and Solutions

- **Unauthorized Reading:**
  - Scan closed boxes and find out what is inside
  - Read RFID enabled credit card or ID (metal foil in passports)
- **Unauthorized Writing:**
  - Can change UPC/price of an item
  - Can kill a tag
- **RFID Zapper:**
  - Can burn a tag using overcurrent
- **RSA Blocker Tag:**
  - Placed near another RFID; prevents its reading
- **Put Tag to Sleep:**
  - Can wake up later; reuse tags
- **Re-label Tag and Dual-Use Tag:**
  - Customer sees differed info or can over-write tag with useful information
- **Authentication:**
  - Reader has to know PIN

Near-Field Communication (NFC)

- **NFC**, is one of the latest wireless communication technologies. As a short-range wireless connectivity technology, NFC offers safe yet simple communication between electronic devices.
- It enables exchange of data between devices over a distance of 4 cm or less.
- NFC operates at 13.56 MHz and rates ranging from 106 kbit/s to 848 kbit/s.

How NFC Works

- NFC is based on **RFID technology** that uses magnetic field induction between electronic devices in close proximity.
- For two devices to communicate using NFC, one device must have an **NFC reader/writer** and one must have an **NFC tag**. The tag is essentially an integrated circuit containing data, connected to an antenna, that can be read or written by the reader.

How NFC Works

- The technology is a simple extension of the ISO/IEC14443 proximity-card standard (contactless card, RFID) that **combines the interface of a smartcard and a reader into a single device**
- An NFC device can **communicate with both existing ISO/IEC14443 smartcards and readers, as well as with other NFC devices**, and is thereby compatible with contactless infrastructure already in use for public transportation and payment
- NFC is primarily aimed at usage in **mobile phones**
- 2015: ~600 million NFC-equipped phones in use (estimate that 5% are used at least once a month)

NFC Applications

There are currently three main uses of NFC:

- **Card emulation:** The NFC device behaves like an existing contactless card
- **Reader mode:** The NFC device is active and reads a passive RFID tag, for example for interactive advertising
- **P2P mode:** Two NFC devices communicating together and exchanging information

NFC Applications

- **Mobile payment**
- **Mobile/electronic ticketing**
- **Smart objects**
- **Electronic keys**
- **P2P data transfers**
- NFC can be used to configure and initiate other wireless network connections such as Bluetooth or Wi-Fi

Future of RFID and NFC